



Microgrid Workshop - May 2, 2002 Workshop Proceedings

Energy Systems Integration Research
Program

Public Interest Energy Research Program
California Energy Commission



Acknowledgements



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Table of Contents



1

Background

2

Results

3

Observations

4

Appendix: Workshop Notes



Background



1

Background

2

Results

3

Observations

4

Appendix: Workshop Notes



The California Energy Commission (CEC) sponsored the workshop to explore different Microgrid concepts and identify current research gaps.

Workshop Objectives

- In support of the overall CEC Public Interest Energy Research (PIER) Distributed Energy Resources (DER) program:
- Present the Consortium for Electric Reliability Technology Solutions (CERTS) Microgrid concept to a working group of key individuals
 - Explore alternative views (i.e., mental models) on definition of Microgrids and related technologies
 - Identify key uncertainties (i.e., research gaps) that need to be addressed for the CERTS Microgrid concept
 - Identify key activities to close research gaps
 - Identify potential high priority areas in Microgrid technology development for CEC PIER funding and activity and possible linkages to existing program activities



The workshop combined presentations and facilitated group discussions in both general assembly and breakout groups.

Workshop Agenda - Thursday May 2, 2002

9:00 - 9:30	Introduction
9:30 -11:15	Microgrid Concept Presentations - <i>CERTS (Bob Lasseter) and Panel Guests</i> (Doug Herman (EPRI), Jon Lynch (Northern Power), Nick Miller (GE Power))
11:15 -12:00	Concept - <i>Facilitated Group Discussion</i>
12:00 - 1:00	Lunch Break
1:00 - 2:15	Research Gaps - <i>Presentations and Discussion in Breakout Groups</i> (There were four breakout groups. Each breakout group worked on a different topic. Each breakout group started with a presentation on research gaps. The presenters and facilitators were: Power Electronics - Mike Ryan (Capstone Turbine) - Facilitated by Stan Blazewicz Protection - Chuck Whitaker (Endecon) - Facilitated by Forrest Small Operations - Joe Iannucci (DUA) - Facilitated by Rob Shelton CHP- Keith Davidson (Onsite Energy) - Facilitated by Jose Luis Contreras
2:15 - 3:15	Actions to Address Gaps - <i>Discussion in Breakout Groups (same as prev.)</i>
3:15 - 4:00	Report Out
4:00 - 4:30	Closing comments and discussion



Workshop participants were divided in specific technology areas (1/4).

Group Title: Power Electronics

Discussant: Mike Ryan-Capstone Turbines

Navigant Consulting Facilitator: Stan Blazewicz

Participants:

1 Brooks, Alec	AC Propulsion
2 Diamond, Joe	Energy Commission
3 Driesen, Johan	UC Berkeley - Electrical Engineering
4 Eto, Joe	CERTS Program Office
5 Galdo, Joe	DOE
6 Ginn, Jerry	CERTS Sandia National Lab
7 Hudson, Ray	Xantrex (Trace Engineering/Technologies)
8 Lasseeter, Bob	CERTS UW Madison
9 Levine, Mark	CERTS Berkeley Lab
10 Soinski, Art	CEC
11 Tirona, Bill R.	PG&E
12 Venkataramanan, Giri	CERTS UW Madison
13 Walde, Len	Sigma Energy Engineering, Inc.
14 Williamson, Chandler	Pentadyme Power



Workshop participants were divided in specific technology areas (2/4).

Group Title: Operations

Discussant: Joe Iannucci-DUA

Navigant Consulting Facilitator: Rob Shelton

Participants:

1 Akhil, Abbas	CERTS Sandia National Labs
2 Canning, Denise	SCE
3 Chuang, Angela	ESCA
4 Doucas, Michael	Engage Networks
5 Erdman, Bill	DUA
6 Gibson, Gerald	Alternative Energy Systems Consulting
7 Haves, Phil	Berkeley Lab
8 Hawkins, David	CAISO
9 Herman, Doug	EPRI
10 Hofmann, Ron	CEC - Consultant
11 Mazur, Mike	Capstone Turbine
12 Miller, Nick	GE Power
13 Nelsen, Paul	Ittron
14 Simpson, Larry	Connected Energy



Workshop participants were divided in specific technology areas (3/4).

Group Title: CHP

Discussant: Keith Davidson-Onsite Energy

Navigant Consulting Facilitator: Jose Luis Contreras

Participants:

1 Alvarez, Manuel	SCE
2 Batham, Mike	CEC
3 Beebe, Bud	SMUD
4 Lee, Steven	UC-Irvine
5 Lipman, Tim	UC-Berkeley
6 Marnay, Chris	CERTS Berkeley Lab
7 Mayer, Max	Navigant Consulting
8 Meorano, Marco	UCI
9 Pace, Stan	Northern Power Systems
10 Rasson, Joseph	Berkeley Lab
11 Skowronski, Mark	CERTS Electric Power Group
12 Teague, Jonathan	DGS
13 Theroux, Michael	Theroux Environmental Consulting
14 Wong, Eric	Cummins West
15 Yee, Dixon	PG&E



Workshop participants were divided in specific technology areas (4/4).

Group Title: Protection

Discussant: Chuck Whitaker-Endecon

Navigant Consulting Facilitator: Forrest Small

Participants:

1 Boyes, John	CERTS Sandia National Labs
2 Ferris, Gene	Mountain Utilities
3 Hitchcock, Ralph	Ralph E. Hitchcock & Associates
4 Horak, John	Basler Electric
5 Kueck, John	CERTS Oak Ridge National Lab
6 Lynch, Jonathan	Northern Power Systems
7 Mazy, Anthony	CPUC/ORCA
8 Michel, Dave	CEC
9 Prabhu, Edan	Reflective Energies
10 Ralph, Mark	Sandia National Labs
11 Skeen, Jim	SMUD
12 Stevens, John	CERTS Sandia National Labs
13 Yinger, Bob	CERTS SCE
14 Zaininger, Henry	Zaininger Engineering Co., Inc.



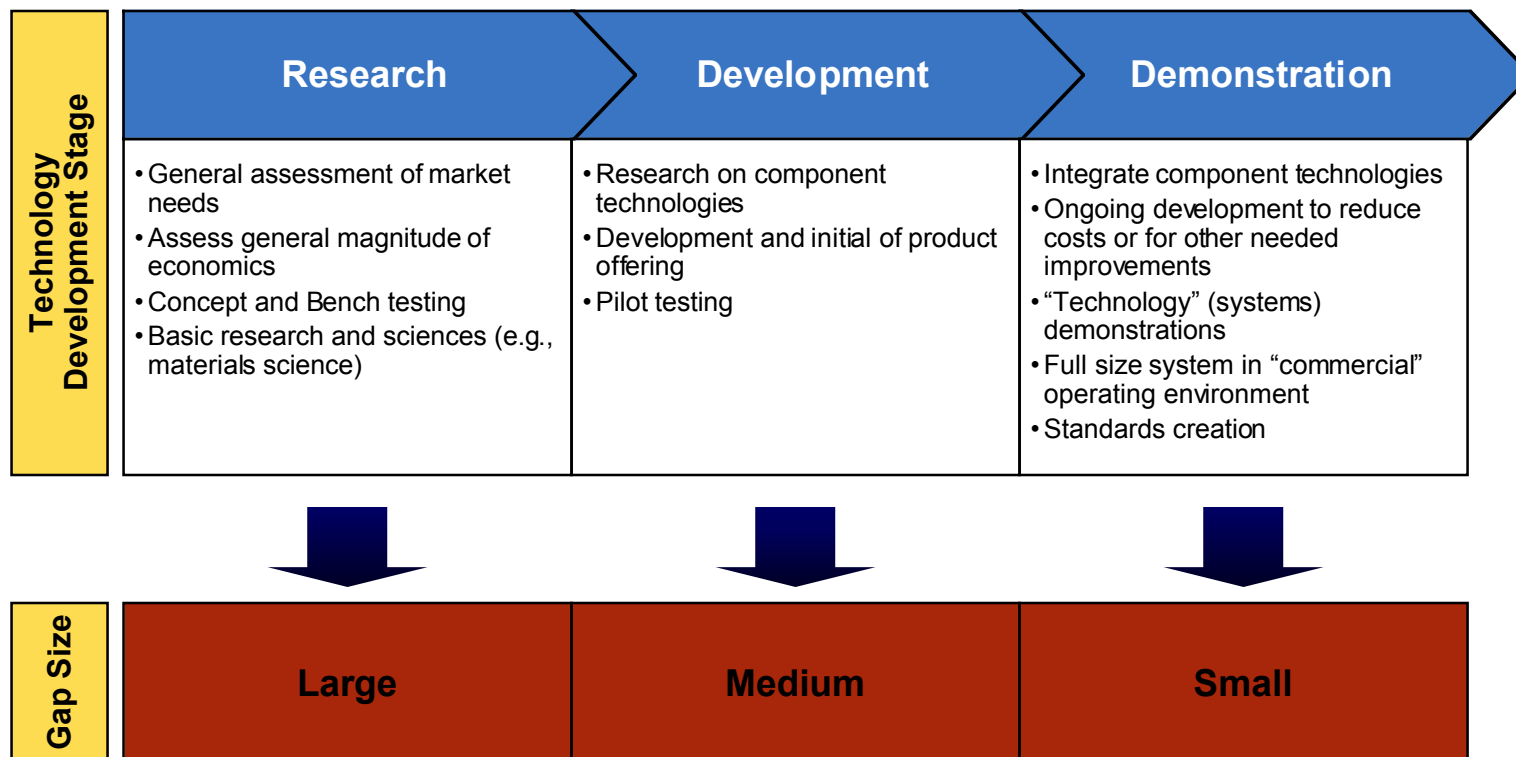
Results



- 1 Background
- 2 Results
- 3 Observations
- 4 Appendix: Workshop Notes



Each breakout group brainstormed research gaps and characterized the gaps (Small, Medium or Large) by technology development stage.





Results Large Technology Gaps



In three of the four technical areas, the breakout groups identified large gaps as well as suggested actions to address them.

Large Technology Gaps and Actions to Close Gaps		
Technical Area	Gaps	Suggested Actions to Address Gaps
Power Electronics	Seamless transition to/from utility at PCC	<ul style="list-style-type: none"> • Separation Device -define seamless based on customer need, classification of separation device • Communication/Coordination of DR - Develop workable architectures, standards for “plug and play”, same protocols as utilities, local smarts to come on and off, algorithm and logic necessary for separation device to island and connect
	Challenging reliability and cost goals	<ul style="list-style-type: none"> • Power Electronics – reduce costs and improve reliability in all kW ranges, heat management, manufacturability, modularity, standardization, component count reduction, tech transfer benefit from automotive, determine performance requirements rather than design for unknown, reliability models and testing • Energy Storage – reduce costs, improve reliability and extend life
	Compliance issues	<ul style="list-style-type: none"> • Establish uniform standards, work with utilities/building inspectors, build testability into power electronics, advocacy, changes to existing standards to allow export, industry association representation on stds committees
Operations	Control/protection algorithms	<ul style="list-style-type: none"> • Develop algorithms
	Multiple connections	<ul style="list-style-type: none"> • Understand implications, define specifications
	Economic model for disaggregated technology operations	<ul style="list-style-type: none"> • Develop model
Combined Heat and Power	Multi-customer electric/thermal/grid monitoring and optimization	<ul style="list-style-type: none"> • Monitor and optimize, find existing potential cases
	Efficiency of heat transformation	<ul style="list-style-type: none"> • Identify what is out there, research alternative materials for thermal conductivity and insulation
	Environmental impacts (noise, vibration, aesthetics, NOx)	<ul style="list-style-type: none"> • External testing, fundamental combustion assessment, system design research, life cycle assessment, research ability to recycle, benefit measurement and valuation, regulatory design
Protection	None: gaps considered to be engineering issues	



Observations



- 1 Background
- 2 Results
- 3 Observations
- 4 Appendix: Workshop Notes



In addition to those identified, other large gaps may exist that are currently masked by the present, ambiguous nature of Microgrids.

- Other technical challenges may be understated or not understood.
 - Competing Microgrid paradigms may have caused some confusion over the actual technology gaps. Those with less aggressive Microgrid concepts saw fewer and smaller gaps.
 - Some of the workshop participants considered that engineering solutions could be found for many of the technical challenges. This was particularly true in the protection area. However, traditional engineering solutions may not be the most elegant, efficient or cost effective approaches. Developing better solutions or completely different approaches may be necessary and require R&D efforts.
- Research, development and demonstration (RD&D) may have to continue with a certain degree of Microgrid definition ambiguity and discover the technology gaps along the way.
 - Microgrids as a concept is still developing and it may take some time to refine definitions and develop business cases.
 - Many of the challenges related to Microgrids are system level issues rather than component level issues. Looking at the components needed to build Microgrids in isolation could be understating or overlooking many of the gaps. When systems based on these components are designed, built and demonstrated more of the system level gaps will be identified.
 - Further research, technology development or business case analysis are likely to uncover more technical issues that were not identified in the workshop.



In addition to technology development, other activities need to be pursued in parallel.

- Evaluate the business case for Microgrids
 - To many of the workshop participants, the business case for Microgrids was not clear. Many felt this was a necessary step in formulating a technology development strategy.
 - Examination of the business case(s) would need to include a better understanding of the values, including how they satisfy customer needs and benefit other key stakeholders (e.g. society, wires company, regulators). A regulatory/institutional discussion should also be included.
- Articulate the challenge
 - Many of the workshop participants struggled with the definition of Microgrids. An unspoken, common definition seemed to be emerging (i.e. Microgrids are an aggregation of loads and generation controlled and optimized with a single grid interface that can seamlessly switch operation from grid connected to island mode.)
 - A single definition or a framework that allows for several definitions may help clarify discussion of microgrid issues. Once this is done the benefits can be identified and the regulatory and technical challenges could be better articulated. Explicit research objectives could then be developed as well.
- Build momentum
 - Some of the workshop participants felt there was a need to deal with evolutionary models – not just end state. Creating a roadmap for Microgrids may be useful in understanding this end state as well as the intermediate steps.
 - Many workshop participants felt it was necessary to develop champions for Microgrids that could act as early adopters, demonstration hosts or founders. Others felt it was important to include utility participants in this effort as well as manufacturing/service providers of waste heat systems.



Appendix



1

Background

2

Results

3

Observations

4

Appendix: Workshop Notes



Appendix: Workshop Notes



This section includes notes from various workshop sessions.

- Outcome from research gap breakout groups
 - Power Electronics
 - Operations
 - Combined Heat and Power (CHP)
 - Protection
- Written comments submitted by workshop participants



The breakout group in power electronics identified seven major gaps. (1/3)

Research Gap	Size	Activities to Close Gap
Seamless transition to/from utility at PCC	L	<p>Separation Device</p> <ul style="list-style-type: none">• Define seamless based on customer need• Classification of separation device<ul style="list-style-type: none">-What is customer need?-What can technology provide?-More engineering than R&D-When to switch R&D gaps on systems side <p>Communication/Coordination of DR</p> <ul style="list-style-type: none">• Develop workable architectures• Standards for “plug and play”• Same protocols as utilities• Local smarts to come on and off• Algorithm and logic necessary for separation device to island and connect
Hybrid modes of DR regulation	M/L	<p>Controls (Software) Development</p> <ul style="list-style-type: none">• Develop and demonstrate sharing power between multiple units• Develop standards• Model Microgrid systems
Power Electronics to provide functionality (e.g., fault current, reactive power, harmonics)	M/L	<ul style="list-style-type: none">• Cost optimization issue• System studies to understand range of needs• Development of algorithm• Type of R&D to determine if grid will provide auto control



The breakout group in power electronics identified seven major gaps. (2/3)

Research Gap	Size	Activities to Close Gap
Challenging reliability and cost goals	L	<p>Power Electronics</p> <ul style="list-style-type: none">• Reduce costs and increase reliability in all kW ranges• Heat management• Manufacturability• Modularity• Standardization• Component count reduction• Tech transfer benefit from automotive• Understand what is needed (design for unknown)• Reliability models and testing <p>Energy Storage</p> <ul style="list-style-type: none">• Reduce costs, increase reliability and extend life• Storage location
Handling of unbalanced / non-linear load content	M	<ul style="list-style-type: none">• System research – what is needed?• Categories/codes/standards
Compliance issues	L	<ul style="list-style-type: none">• Establish uniform standards• Work with utilities / building inspectors• Build testability into power electronics• Advocacy• Changes to existing standards to allow export• Industry association representation on standards committees



The breakout group in power electronics identified seven major gaps. (3/3)

Research Gap	Size	Activities to Close Gap
DC topology	M	<ul style="list-style-type: none">• Architecture studies• DC distribution and Microgrid advantages – better power quality control?• Does it make sense?• Alternative architectures for Microgrids• Research new power electronics to get higher power level, lower cost (silicon carbide)



The breakout group in operations identified sixteen gaps. (1/2)

Research Gap	Size	Activities to Close Gap
Define communication issues <ul style="list-style-type: none">- Sub cycle vs. multiple cycle- Network architecture- Define topology	M/L	<ul style="list-style-type: none">• Topology definition• Functional definition
Develop control/protection algorithms	L	<ul style="list-style-type: none">• Develop algorithms
Multiple connections	L	<ul style="list-style-type: none">• Understand implications• Define specifications
Develop economic model for disaggregated technology operations	L	<ul style="list-style-type: none">• Develop model
Develop economic model for aggregated technology operations	S	<ul style="list-style-type: none">• Develop model
Engineering model of generation and load	M	<ul style="list-style-type: none">• Develop model
Design tool to link operation (engineering/economic)	M	<ul style="list-style-type: none">• Develop tool
Diversity of DG and invertive technologies	M	<ul style="list-style-type: none">• Model and/or test



Appendix: Workshop Notes Research Gaps Breakout Session Operations



The breakout group in operations identified sixteen gaps. (2/2)

Research Gap	Size	Activities to Close Gap
Regulatory rules / support	M	<ul style="list-style-type: none">• Research market/regulatory/business models• Act on findings
Plug and play control standard	M	<ul style="list-style-type: none">• Develop standards
Grid restoration issues (negatives)	M	<ul style="list-style-type: none">• Understand issues• Field testing
Multiple customer (policy and regs)	M	<ul style="list-style-type: none">• Research market/regulatory/business models• Act on findings
1547 revisions	S	<ul style="list-style-type: none">• Rule 21
Operational information – electricity and fuel prices, environmental restrictions and other data to make decisions to operate; where to get the information	S	<ul style="list-style-type: none">• Study
Energy production forecasting	S	<ul style="list-style-type: none">• Research model development
Understand existing technology maps to MG	S	<ul style="list-style-type: none">• Identify and assess systems (e.g., TX)



The breakout group in CHP identified fourteen gaps. (1/2)

Research Gap	Size	Activities to Close Gap
Multi-customer electric/thermal/grid monitoring and optimization controls	L	<ul style="list-style-type: none">• Monitor and optimize• Find existing potential cases
Accommodating different customer/load reliability requirements	S	<ul style="list-style-type: none">• Characterize loads• Design practices to integrate CHP into a high reliability design
Dispersed CHP interconnectivity	M	<ul style="list-style-type: none">• Demo physical systems• Info transfer (e.g., Europe)• Develop low cost thermal meters
Lower cost thermal recovery devices and distribution systems	M	<ul style="list-style-type: none">• Design for manufacturing and assembly• Cost reduction through improved efficiency
Efficiency of heat transformation	L	<ul style="list-style-type: none">• Identify what is out there• Research alternative materials for thermal conductivity and insulation
Process and economic modeling <ul style="list-style-type: none">- Multi use- System optimization	M	<ul style="list-style-type: none">• Develop compatible modules• Modeling tools• Standardize equipment specifications
Optimization of heat recovery	M	<ul style="list-style-type: none">• Develop modeling tools• End user characterization• Better resolution of time-heat data
Communication among users	M	<ul style="list-style-type: none">• Identify barriers• Develop and optimize protocol
CHP potential for each DG tech <ul style="list-style-type: none">- Rating/standards testing- Front end / back end engineering	M	<ul style="list-style-type: none">• Develop rating standards• External validation• Develop testing protocols



The breakout group in CHP identified fourteen gaps. (2/2)

Research Gap	Size	Activities to Close Gap
Technology transfer from larger conventional systems to smaller systems (e.g., absorption chillers) - Performance/cost match	M	<ul style="list-style-type: none">• Identify specific transfer applications• Design standards and packaging of components
Environmental impacts (noise, vibration, aesthetics, NOx)	L	<ul style="list-style-type: none">• External testing• Fundamental combustion assessment• System design research• Life cycle assessment• Research ability to recycle• Benefit measurement and valuation• Regulatory design
Lack of outreach tools	S	<ul style="list-style-type: none">• Develop case studies• Educational upgrades• Mechanisms for disseminating info
Gas usage metering	M	<ul style="list-style-type: none">• Develop one-minute real time meter and deploy them
Small scale heat metering	S	<ul style="list-style-type: none">• Develop one-minute real time meter and deploy them



Appendix: Workshop Notes Research Gaps Breakout Session *Protection*



The breakout group in protection identified ten minor issues.

Research Gap	Size	Activities to Close Gap
- Fault detection	S	• Engineering work
- Abnormal conditions	S	• Engineering work
- Speed of response	S	• Engineering work
- Resynchronization	S	• Engineering work
- Microgrid controls – high speed	S	• Engineering work
- Nuisance separation	S	• Engineering work
- Stability	S	• Engineering work
- Microgrid value (reliability, PQ, efficiency)	S	• Engineering work
- Transaction size	S	• Engineering work
- Standardization of Microgrid devices	S	• Engineering work



Written comments submitted by participants describe the reactions from some parties to the workshop.

Summary of submitted comments:

- “Significant additional research, development and demonstration must occur before the Microgrid concept is embraced”
- “The debate before us should be how to best design an effective and unbiased research effort”
- “SCE (Southern California Edison) stands ready to apply our distribution and distributed generation testing expertise to help the CEC assure the best system for all”
- “Participation of the distribution utility in this process is critical to alleviate problems with future installations”
- “CEC (should) engage in an approach designed to first test and understand the implications of Microgrids before developing and promoting policies designed to encourage their use”